DOCUMENT RESUME

ED 289 492 IR 012 959

AUTHOR	Ellington, Henry
TITLE	How Computers Can Be Used in Tertiary Education. Teaching and Learning in Higher Education, 9.
INSTITUTION	Scottish Central Institutions Committee for Educational Development.
SPONS AGENCY	Robert Gordon's Inst. of Technology, Aberdeen (Scotland).
PUB DATE	87
NOTE	19p.; For a related guide, see IR 012 968.
PUB TYPE	Guides - Non-Classroom Use (055) -- Information Analyses (070) -- Reports - Evaluative/Feasibility (142)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Computer Literacy; *Computers; *Computer Uses in Education; Courseware; Databases; Foreign Countries; Higher Education; Programing; Teacher Attitudes

ABSTRACT

The first of three parts of this booklet, which assumes no previous knowledge of computers or programming, explains what computers are and briefly describes the components of a computer system. The second section examines the different ways in which the computer can be used in higher education, including its use: (1) as a "super calculator"; (2) to teach about computers and programming; (3) as a direct aid to the teaching/learning process; (4) in an administrative or managerial role; and (5) as a database. The third section discusses technical factors, factors relating to the availability of software, attitudinal factors, and other factors affecting the educational use of computers. An annotated list of four references recommended for further reading is included. (MES)

This booklet was first published internally in Robert Gordon's Institute of Technology, Aberdeen as part of the Institute's staff development programme.

The booklet was produced by Dr Henry Ellington of RGIT's Educational Technology Unit, who adapted it from material originally published in "A Handbook of Educational Technology", by Fred Percival and Henry Ellington (Kogan Page, London; 1984).

CICED gratefully acknowledges the co-operation of RGIT, Kogan Page and the authors in the publication of the present edition of the booklet.

How Computers can be Used in Tertiary Education

Introduction

This booklet, which assumes no previous knowledge of computers or programming, is divided into three main sections. The first explains what computers are and describes (in simple terms) the functions of the different components of a computer system. The second examines the different ways in which the computer can be used in tertiary education, looking at its use as a 'supercalculator', its role in computer-assisted and computer-managed learning and its use as a data base. The third discusses some of the factors that affect the educational use of computers – technical factors, factors relating to the availability of software, attitudinal factors, and so on.

A further booklet in the CICED series, (number 18) gives detailed guidance on how to produce computer-based learning materials of the various types described.

Basic concepts and terminology

A *computer* can be defined as a device which is able to accept information, apply some processing procedure to it, and supply the resulting new information in a form suitable to the user.

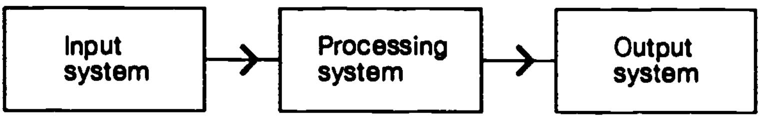
The great majority of modern electronic computers – particularly those that are used for educational purposes – are *digital computers*. By this, we mean that the information that they handle is converted into *digital* form (i.e. into a code based on the *binary number system*, which only uses two symbols – 0 and 1) before processing. Computers that are designed to handle data which has *not* been converted into digital form are known as *analogue computers*, and are mainly used for specialised technical or scientific purposes.

Digital computers are themselves, subdivided into *mainframe computers*, *minicomputers* and *microcomputers*. *Mainframe computers* are large, highly-expensive machines (costing at least several hundred thousand pounds) which normally require a custom-built suite of rooms in which to house them and a highly-trained team of staff to operate them – the sort of machines that are installed in the central computer units of large organisations and educational institutions. Next, we have *minicomputers*, which are basically simpler, cheaper versions of mainframe machines – the type of computers that might well be used by a small business or college or

by a major section of a larger organization. Finally, we have *microcomputers*, small, 'desktop' machines that can be purchased for as little as a few hundred pounds and can be used for a wide range of purposes – everything from straightforward calculations to word processing and interactive video. These are the machines that are now finding their way into our schools and colleges in ever larger numbers.

All computers consist of three basic sub-systems, as shown in schematic form in Figure 1.

Figure 1: a simple schematic diagram of a computer system



The first of these is the *Input system* i.e. the system whereby information is fed into the computer. This information can be of two types, namely, *instructions to the computer* (the so-called *computer program*, written in a special code – known as a *programming language* – whose nature depends on the nature of the computer and the specific use to which the program is to be put) and *data* (the material on which the computer will actually operate). Both types of information can be fed in via a wide range of systems, but the one that readers are most likely to encounter is the *keyboard terminal*, a typewriter-like device whereby instructions or data can be fed directly into the computer to which it is connected. Instructions and data can also be fed into a computer in the form of coded patterns of holes in punched cards or tape, coded patterns of magnetic pulses on magnetic tape or discs, or patterns of bars or symbols that can be 'read' using a variety of optical scanning devices. Other methods of communicating with computers (eg by speech) are currently being developed.

The second major part of a computer system is the *central processing unit* (or CPU) – the part where the actual processing of the material fed into the computer takes place. This itself consists of three separate sub-systems, namely the *memory* system (where instructions and data are stored in coded form), the *arithmetic and logic unit*, or ALU (where standard arithmetical and logical operations are applied to the coded signals that represent these instructions and data) and the *control unit* (which co-ordinates all the functions of the CPU by interpreting and executing instructions held in the computer memory).

The output of a computer can be presented in three different ways. First, it can be produced as so-called *hard-copy*, – alphanumeric or graphical information that is actually printed on paper using a device such a *line printer* or *graphical plotter*. Second, it can be produced in the form of so-called *soft-copy* – similar information that is temporarily displayed on the screen of a *video display unit* (a device similar to a television set). Third, it can be produced in the form of a coded signal of some sort, a signal that can either be used directly for some immediate purpose (eg control of another machine or system) or passed into a storage system for future reference or use. Storage systems that are used for this purpose include punched cards and tape, magnetic tape and discs, and a variety of 'optical' devices such as videodiscs.

The Different Roles of the Computer in Education

Since the 1960's, the range of uses of the computer in education has expanded considerably. At first, its role was largely confined to that of a 'supercalculator', but it is now also used in a wide variety of other ways, some of the more important of which will now be examined.

Use of the computer as a 'supercalculator'

This was the original – and, for some time, only – role of the computer in education, namely, as a tool for carrying out complicated and/or time-consuming calculations as part of academic research programmes. Digital computers are, of course, ideally suited to this form of use, since they enable calculations that would previously have taken hundreds or even thousands of man-hours to be completed in a matter of minutes. As computers become progressively more powerful, their usefulness in this role continues to increase steadily, and they have now become an indispensible research tool in a wide range of subject areas.

Nor is the use of the computer as a 'supercalculator' limited (as was often previously the case) to research scientists and academic staff of universities and large colleges. In many tertiary education establishments, students of all levels – from first-year undergraduates to postgraduate research students – are making increasing use of the computer as a tool in their day-to-day work. As a matter of routine, students now use computers to calculate the slopes of graphs, carry out statistical tests on data, and compute the results of experiments – tasks that were, until comparatively recently, all carried out manually using such 'stone-age' aids to calculation as slide-rules or logarithmic tables. The availability of computers (and

their near-relatives, pocket calculators) to carry out calculations of this type has already had an impact on education, particularly at secondary and tertiary level, that can truly be described as revolutionary.

Use of the computer to teach about computers and computer programming

Following on naturally from their original applications in academic research, computers eventually started to be used for teaching *about* computers and computer programming. During the 1970's, this use of the computer became increasingly widespread, until, at the present time, there is hardly a secondary school or tertiary education establishment in the industrialised world that does not include at least *some* computer science or computer programming in its curriculum.

Furthermore, this teaching of basic computer literacy is no longer confined to students of mathematics or computer science and students in traditional computer-using disciplines such as science and engineering, as was largely the case until comparatively recently. It is now becoming increasingly widely recognized that virtually *all* tomorrow's citizens will have to acquire such literacy if they are to be able to cope with the technological complexities of everyday life - or, at the very least, should be given an idea of the vital role of computers in the modern world. Clearly, the use of computers as vehicles for the achievement of these various educational goals is almost certain to continue to increase.

Use of computers as direct aids to the teaching/learning process.

A third way in which computers have been able to make a major contribution to education and training is in *computer-assisted learning (CAL)*, in which the computer plays a key role in the actual teaching/learning process. When employed in this role, the computer is normally used in one of two distinct modes (although in some cases, it is used in a combination of the two). In the first, the computer acts as s *substitute tutor* with which the student can undergo an on-going dialogue via an interactive terminal of some sort. In the second, it acts as a kind of *simulated laboratory*, providing facilities whereby the student can carry out 'experiments' on a model system that has been programmed into the computer. Because of the importance of these two modes of operation, we will now examine them in some detail.

7

(a) *The 'substitute tutor' mode*

In the 'substitute tutor' mode, the student interacts directly with the computer, which is programmed to react to student responses to the questions which it sets. The computer may then ask supplementary questions, or provide additional learning information, before requiring the student to respond once more. This adaptive style of learning is directly descended from the *programmed learning* movement of the 1950's and 1960's. It is essentially similar to 'branching' programmed learning, but is capable of being much more sophisticated than the latter because of the greater flexibility and data-handling capacity of computers compared with early 'teaching machines' or programmed texts. For example, in 'tutor' mode CAL, a student may not be directed to a remedial exercise purely on the basis of a single response; his pattern of responding over a period of time, or even over an entire lesson, may be taken into account by the computer. Such a facility is obviously very useful when basic skills such as mathematical or reading skills are being learned.

Normally, tutor-mode CAL may be just one of the several self-instructional techniques that are employed in a given student-centred educational or training situation. Such a combin tion of approaches obviously leaves room for flexibility, and allows a close matching of teaching methods with course objectives to be achieved.

When a computer is used interactively in a self-instructional capacity, the form of the student responses is dependent upon the sophistication of i) the computer, and ii) the computer program. A simple programme may require a student to respond to a given question from a multiple-choice set of options by typing in the code for the selected response. More sophisticated packages may allow the student to respond freely in his own words, the computer being programmed to identify key words, phrases, or numbers, and to respond accordingly.

An example of a section of interactive dialogue between a student and a computer is given in Figure 2. In this, the computer is assisting the student to plan a chemistry experiment, and the student may in fact investigate various possible experimental methods by interacting several times with the computer. In the dialogue, the student responses are italicized.

8

Figure 2: extract from a 'tutor' mode CAL dialogue

You are required to investigate experimentally the chemical equilibrium of the system: $Fe^{3+} + SCN^{-} \rightleftharpoons FeNCS^{2+}$ in order to discover how the equilibrium constant varies as a function of the ionic strength.

You need a method which is both sensitive and discriminating. Which method(s) do you suggest?

I'm sorry, but I haven't a clue

You first need to consider the physical properties of the individual species, or of the system as a whole, which you might use. What features do all the species involved have in common?

They are all ionic

Good!
So what method or methods might you choose which makes use of this property?

Conductivity methods

Yes - a conductance method.
Is a conductance method sensitive? (Very, Fairly, Not very, Not at all)

Very

No. A conductance method is only fairly sensitive.
Is it a discriminating method?

Yes

Conductance methods are only really discriminating when applied to H^{+} ions: for all other ions, the readings are rather similar.

Do you want to consider this method further?

No

What other method(s) might be more discriminating and sensitive?

Possibly a colourimetric method

Good. Are colourimetric methods sensitive?

and so on

(b) *The 'simulated laboratory' mode*

In the 'simulated laboratory' mode, the computer is more of a 'learning resource' than a direct instructional device. In this mode, practical situations can be modelled on the

computer, thus allowing the system to be studied as changes are made to key variables. The simulated practical situations can come from a wide variety of subjects, and developments in computer simulation have taken place in such diverse areas as medicine, engineering, geography, mathematics, the physical sciences, economics, business and management training, and military training.

Examples of situations which might point to the use of computer simulations include the following:

situations where a conventional practical demonstration is either extremely difficult or impossible (eg in manipulating a country's national economy);

situations where the apparatus or machinery required is either not readily available or is too complicated or expensive for general classroom use (eg in training off-shore oil drilling personnel);

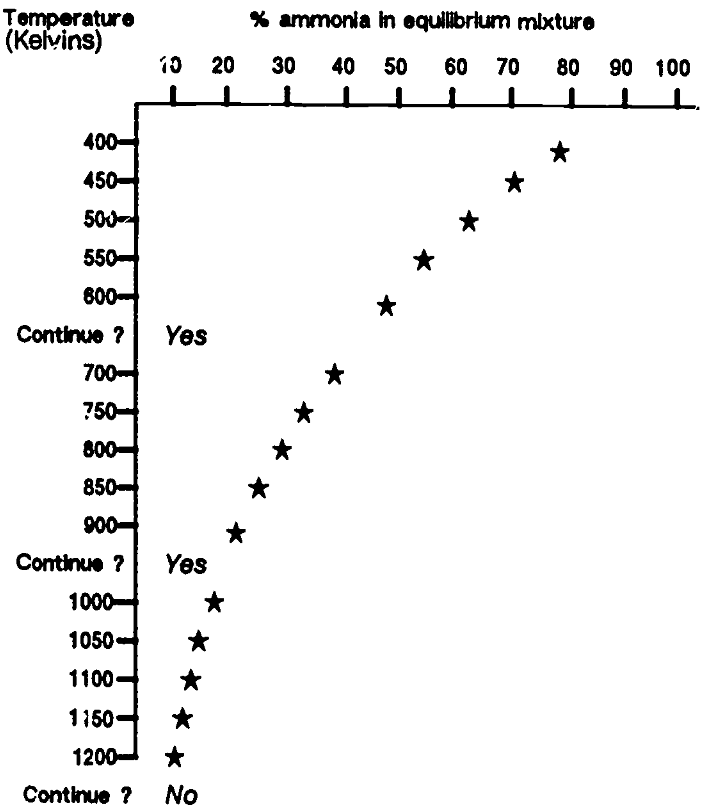
situations where a conventional, real situation would take an unacceptably long time to investigate (eg experiments in population dynamics or genetics).

Figure 3 gives an example of a 'laboratory mode' CAL application. In this case, a complex, highly-expensive industrial process (the production of ammonia) has been modelled on the computer. This process is impractical to carry out in the science laboratory due to the high pressures involved, but, with the aid of the computer, students are able to discover the effects of altering various conditions (temperature, pressure, and reactant concentration ratio) on the efficiency of the process. When interacting with the computer, the students enter simple replies to the computer's requests for information. Figure 3 shows a sample print out, with the user's inputs again italicized.

Use of computers in an administrative or managerial role

Yet another area in which computers have been used in education is in an administrative or managerial role, helping with such things as the overall administration of the system, time-table planning, budgetary control and the management of the teaching/learning process.

Which factor do you wish to vary?
Type 1 for reactant ratio
2 for temperature
3 for pressure 2
What is the value for the reactant ratio? 3
What is the value for the initial temperature (Kelvins)? 400
By how much does the temperature increase with each step? 50
What is the value of the constant pressure (atmospheres)? 300



Do you want to run the program again? *No*
End of program

Figure 3: sample print out from a 'laboratory simulation'

In this last role, which is known as *computer–managed learning (CML)*, the computer does not make a direct contribution to the

teaching/learning process, as is the case in CAL. Rather, it acts in a supportive and/or supervisory role, relieving the teacher or trainer of various tedious or time-consuming managerial tasks and thus allowing him or her to devote more time to the actual job of teaching and to meeting the specific needs of individual students. Thus, in a smoothly running CML environment, there is a balanced partnership between the teacher, the students and the computer.

In CML, the role of the computer is largely clerical, although it could be argued that it is more efficient and cost effective than human clerical assistance could ever be. There are four roles normally associated with the computer in a CML system. First, it can generate, mark and analyse tests for diagnostic or assessment purposes. Second, based on what is previously known about each student and about the structure of the course, it can provide individual guidance to each student, directing or advising him or her on the best choice of route through a structured set of course materials or modules; this is normally based on the assumption that the majority of students should follow one of a limited number of well-defined routes. Third, the computer can be used to store and update records of test performance and progress through the course. Finally, from its accumulated records, it can report on the progress of the student body as a whole, and on the operation of the course in general, to individual students, the course tutors, and the course planners. The emphasis on each of these four factors will obviously vary according to the particular requirements of a given CML approach, although the administration and operation of *assessment* is at the heart of most CML applications.

With properly-constructed computer-marked tests, the marking is (by definition) totally reliable. However, this normally restricts the type of questions to the different forms of objective items such as multiple-choice questions and structural communication tests (see CICED booklet number 20 on 'Student Assessment'). The tutor time saved by utilizing computer-based assessment can be considerable, and can allow a teacher to allocate a greater proportion of his or her time to direct student contact.

Use of the computer as a data base

Although most people tend to think of the computer mainly as a machine for carrying out complicated calculations with great speed and accuracy, its ability to store and facilitate the subsequent retrieval of information is equally important. Indeed, it is this latter feature that has led to one of the most important uses of the computer in modern society, namely, as a *data base*.

One of the first manifestations of the 'new information technology' explosion that is currently changing the nature of industrial society was the establishment of vast computerised repositories of information like the US-based ERIC system and the British PRESTEL interactive videotex system. These differ from conventional reference libraries and data banks in that the information they contain is stored electronically, and can be accessed from virtually any distance using a remote computer terminal connected to the central computer by telephone link. The development of such computerized data bases has not only revolutionized the world's library systems, but is also having a tremendous impact on education – particularly at tertiary level. Students who wish to carry out a literature search in a given field, for example, no longer have to do so manually, but, by linking up with the appropriate bibliographic data base (which is often located on the other side of the world) can obtain abstracts of virtually every paper, article or book that has ever been written on the subject in which they are interested.

It is, of course, also possible to make use of the information-storing capacities of the computer at a more 'local' level by, for example, creating custom-built 'data-bases' for specific educational purposes like the two described below.

Example 1 Much of the work that is requested of students is often boring and repetitive. If, for example, it is necessary to take twenty readings during the course of a lengthy scientific experiment, it may not be educationally necessary, or desirable, for the students to repeat the actual practical activity more than a couple of times. By feeding his or her first few results into a computer in which a suitable data base has been established, the computer may then generate the required number of additional readings, which the student can then examine and interpret just as if he had obtained them himself. In a similar way, use of a suitable computer data base can often save students from having to carry out repetitive calculations.

When using the computer in this manner, it is necessary for the teacher to distinguish between appropriate tasks and inappropriate (often time-consuming) tasks associated with the achievement of given goals. Very often, a balance can be struck in which the computer can be used to eliminate the main burden of the latter while still retaining those

tasks that are essential to the student's development.

Example 2 Writing and validating questions for use in objective tests is an extremely difficult and time-consuming task. Thus, once a suitable question of this type has been produced, it should not simply be used on a 'once off' basis, but stored for future use. The computer represents an ideal vehicle for this type of storage, and can be used to build up an extensive bank of objective questions over the years. Specific questions can then be culled from such a bank for particular purposes – by, for example, calling up all questions containing certain keywords and then selecting the most suitable by inspection.

Factors affecting the educational use of computers

There is no doubt that computers and 'new information technology' are potentially capable of causing profound and far-reaching changes in our educational system – changes that are at least comparable to those that were eventually brought about by the mass use of the 'old information technology' of the printing press. We will now discuss some of the factors that are likely to determine to what extent – and at what rate – the 'computer revolution' will be realised.

Technical factors

Although enormous progress has been made during the last ten years, there are still a number of technical factors that militate against the widespread use of computers in our schools and colleges.

Probably the most important is the fact that it is still generally necessary to learn what are basically new languages (the various programming languages) in order to be able to communicate effectively with computers – something than undoubtedly prevents large numbers of people from even trying to use computers in their work or studies. It is true that 'user friendly' software packages, which do not require users to be familiar with the programming language in which the program is written, are becoming increasingly available, but there is still a long way to go before the communication barrier is completely broken down. Indeed some commentators believe that computers will only achieve universal acceptance when users can actually talk to them using ordinary language – as in 'science fiction' situations such as "Star Trek". Given the

phenomenal rate of progress in computer development, that day may not be all that far off.

Other technical problems relate to the use of the 'time sharing' mainframe computers that have now been set up in most of our large colleges and universities. Here, students gain access to the machine via remote terminals, and (unless they are lucky enough to be carrying out their studies in an institution that has enough terminals to meet the peak demand) often experience difficulties in gaining access to a terminal when they want it. Even when they *do* succeed in gaining such access, they often find that the machine is so overloaded with work from other people that they experience long and frustrating delays in having their own material processed. In time, an equilibrium is generally established, but not necessarily one that meets with the needs of the students, who often have their motivation to use the computer reduced as a result. Nor is the problem necessarily removed by increasing the capacity of the machine, since each successive enhancement merely leads to an increase in usage which very quickly causes the system to become saturated once again. Thus, most central computer service units in colleges and universities find themselves trapped in a perpetual "Catch 22" situation! No doubt these problems will eventually disappear as time-sharing machines become progressively capable of handling more and more users without undue delays, but, for the foreseeable future at any rate, they will probably remain with us.

Technical problems are not limited to the 'hardware' side of computer operations, since serious difficulties can often arise regarding the compatability of software, i.e. the use of software that has been designed for use with one type of machine on other machines. Such problems even arise with software 'packages' that are designed for use with a variety of machines, since technical standards regarding programs and supportive documentation are seldom rigidly adhered to. Compatability problems have become even greater in recent years with the proliferation of different types of microcomputers, but, as in the case of the other technical problems that are associated with the educational use of computers, these are probably merely 'teething troubles' that will be overcome in the not-too-distant future; there appears to be no intrinsic reason why this should not prove to be the case.

Factors relating to the availability of software

With the advent of inexpensive, portable microcomputers, virtually every educational and training establishment in the developed world now has access to *some* form of computer hardware. However, while hardware costs are steadily decreasing and computer capacity and

sophistication are steadily increasing, appropriate *educationally-useful* software packages still need to be developed, and this is proving both difficult and time-consuming. Thus, many institutions are finding themselves in a position where they have access to highly-sophisticated computer hardware, but are not in a position to make proper use of it due to lack of suitable software. It was in fact just such a lack of software that prevented teaching machines from making any lasting impact on our educational system.

Given that it can take up to several hundred skilled man-hours to produce, document and validate a *single hour* of high-quality computer-assisted learning material, it is clearly not realistic to expect the average college lecturer to produce all his own software. Even if he or she had all the appropriate skills (a high degree of programming ability, a feel for educational design, ability to write supportive documentation, and so on) the time element would effectively preclude his/her producing anything more than a tiny fraction of the material he/she would need to support even a comparatively short course.

Provided that high-quality material was available from other sources, this would cause no real cause for concern (after all, no-one expects teachers and lecturers to write their own textbooks). However, with a few honourable exceptions (eg the packages produced by centres of excellence such as Chelsea College, London and the State University of New York), much of the commercially-available CAL software that has been produced to date is (to quote one commentator): "of dismal quality, poorly documented, gimmicky and unimaginative, some of it actually dangerous in the sense that prolonged inexperienced use could lead to the perpetuation of maladaptive strategies and the learning of errors". No doubt the situation will improve, but, unless there is a really massive commitment to the production of high-quality software that is capable of making a significant contribution to the main-line teaching work of our schools and colleges, it is doubtful whether computer-assisted learning will ever make the impact of which it is potentially capable.

Attitudinal factors

Another factor that will almost certainly have a considerable influence on the extent to which computers are used in our educational system is the attitude of teachers and lecturers. Here, as in the case of other fields in which an attempt is being made to introduce revolutionary new technology, there is a very real danger that the people who will actually have to use it will see it as a threat to their jobs, authority or traditional role, and, as a result, will fail to provide the cooperation that is necessary for the success of the innovation.

Two recently-reported examples clearly illustrate these potential problems. The first was an attempt by one of the largest school districts in the American State of Utah to introduce a comprehensive computer-managed learning system covering virtually the entire curriculum. Based on the concepts of skill mastery learning, the system established specified goals, and provided schools with criterion-based pre- and post-tests together with the appropriate learning strategies and resource materials. The entire system was monitored and administered via the district's central computer, which marked the tests, indicated remedial strategies where appropriate, and decided when students should progress to new work.

This highly-sophisticated and innovative scheme was developed by dedicated teams of teachers and curriculum specialists, all of whom subsequently spoke with considerable enthusiasm about the resulting educational benefits. In the case of the great majority of teachers, who had not been directly involved in the development process, on the other hand, the attitude to the scheme was radically different. Many of these felt that their traditional role had been 'usurped' by the computer, and also resented the fact that their efficiency as teachers was effectively being measured by the on-going programme of diagnostic tests. Thus, although there had hitherto been no history of teacher union militancy in Utah, the teachers demanded – and eventually achieved – the partial dismantling of the control mechanism and the adoption of a more voluntarist strategy on the part of the district administration.

The second example involved an attempt by an (unnamed!) English polytechnic to introduce a comprehensive personnel management system, based on the use of a central computer to store detailed information about the expertise, timetables and availability of individual members of staff. It was intended that this information would be used to monitor the accuracy of timetabled information, and to provide more precise data concerning the distribution of teaching activities, student group attendance, teachers' work loads, etc. In the event, requests for the relevant information were simply ignored by the majority of staff involved, thus rendering the system ineffective.

In both these examples, the availability of new computer-based technology encouraged educational administrators to attempt to introduce systems which they confidently expected would improve the efficiency of their organizations. In both cases, however, the innovations met with strong resistance from the teaching staff involved, who felt that their traditional working practices and professional autonomy were under threat. Clearly, any attempts to

introduce innovation of this type are foredoomed to failure unless the cooperation of the teachers involved can be obtained, and it is obviously necessary to proceed with great caution.

Other educational factors

Other factors that are likely to affect the extent to which computers are eventually used in our educational system are of a philisophical rather than a practical nature.

There is, for example, a very real fear among some educationists that the ever-increasing use of computers and other aspects of new information technology will lead to an over-dependance on *mediated learning* as opposed to learning through direct experience (what Bruner and his co-workers call *enactive learning*). Such educationists argue that there is a need to preserve a balance between the two types of learning, since it will never be possible to provide children with a properly-rounded education by mediated learning alone.

Another argument that is sometimes put forward against the increased use of computer-based technology in our schools is that there is a danger that it will lead to a new form of educational elitism. Some children (it is argued), but not the majority, will gain 'computer literacy' and take advantage of whatever becomes available through the technology that this literacy opens up to them. The very real danger of the emergence of such a new elitism is recognised by several commentators, including computer enthusiasts.

Finally, there is concern in some quarters that the increasing reliance on computer-based learning and new information technology will weaken our traditional public educational systems, thus causing lasting and possibly irreparable damage to the fabric of society.

Two types of argument are put forward in support of this view. The first maintains that new information technology is likely to prove too expensive to be adopted on a really large scale by the public educational sector, and that its undoubted benefits will therefore be limited to the private sector, which will progressively 'cream off' substantial numbers of able students whose parents can afford to pay for their education. This, it is argued, could lead to the eventual demise of the public system as an effective educational force – with all the potential social damage that this would produce.

The second argument maintains that new information technology will eventually become so cheap and efficient that existing educational systems will be rendered obsolete, being replaced by individualized learning carried out at home or at work. Thus, face-to-face instruction will become a rarity, with a resulting imbalance between

mediated and enactive learning that will be extremely undesirable from an educational point of view.

Conclusion

If computers are to be used *effectively* in education and training, then they must be used *appropriately*, and their use will certainly not flourish if they are seen merely as an expensive alternative to the classroom teacher. Care must be taken to identify and develop, through the computer, learning opportunities which cannot easily be provided in any other way. In other words, the undoubted strengths of computers must be made the most of; it is in no–one's interest simply to use them because of their availability, or to employ them as 'gimmicks', as is all too often the case at the moment. Computers have, in principle, the potential to revolutionize our educational system; let us hope that the opportunity is not lost due to lack of action or mis–use, and that they do not suffer the same fate as the teaching machines which showed such early promise during the 1960's.

Further Reading

1. *An Introduction to Educational Computing*, by N J Rushby; Croom Helm, London, 1979. (A highly–readable introduction to the subject that assumes no previous knowledge of computers or computing. Available in paperback.)

2. *A Handbook of Computer–Based Training*, by C Dean and Q Whitlock; Kogan Page, London, 1983. (Another highly–readable introduction to the instructional use of computers; somewhat more advanced that the Rushby book.)

3. *New Information Technology in Education*, by D Hawkridge; Croom Helm, Beckenham, 1983. (A thought–provoking book that should be set reading for all teachers and educationists; a non–technical survey of the potential role that computers and other aspects of 'new information technology' are capable of playing in education and society.)

4. *World Yearbook of Education 1982/83 – Computers and Education*, edited by J Megarry, D R F Walker, S Nisbet and E Hoyle; Kogan Page, London, 1983. (An extremely useful collection of articles dealing with virtually all aspects of the educational use of computers.)